Seasonal distribution, abundance and habitat use of foraging wading birds in the Charleston Harbor Estuary, 1994.

Project: CHP 94 - 1.4, Habitat Identification - Birds

Final Report

by

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ABSTRACT

Because of concern over increasing residential and industrial development, we examined gross patterns of seasonal abundance and habitat use of foraging wading birds in the Charleston Harbor Estuary, South Carolina. We conducted boat surveys of 759 km of shoreline habitat from January - December 1994. We divided the estuary into 6 survey routes representing four river drainages (upper estuary), Charleston Harbor, and surrounding salt marsh habitat (lower estuary). On a finer scale (within survey route), we examined wading bird use of three brackish-marine habitats [mudflats, small creeks (< 50 m width), estuarine shoreline] and four freshwater habitats [impounded wetlands, formerly impounded ricefields, riverine shoreline, small creeks (< 50 m width)]. Abundances of foraging wading birds were high from June-September (1495-2244 birds) compared to October-February (428-681 birds). Great Egrets (*Casmerodius albus*) accounted for 46, 39, and 47% of the total foraging birds during July, August, and September, respectively. The abundance of wading birds was significantly and positively correlated with total fish biomass ($R = 0.80$, $\underline{P} = 0.002$). Of the four most abundant species, only Great Egrets ($R = 0.83$, $\underline{P} = 0.001$) and Snowy Egrets (*Egretta thula*; $R = 0.78$, $\underline{P} = 0.003$) were significantly correlated with total fish biomass. There was no difference in densities of foraging wading birds between survey routes ($P = 0.45$). On a finer scale, wading birds utilized mudflats, formerly impounded ricefields, and small creeks (brackish-marine) at higher densities than other habitats ($\underline{P} = 0.0001$). When species patterns were examined, Great Egrets also foraged at higher densities in mudflats, formerly impounded ricefields, and small creeks (brackish-marine). Tricolored Herons and Snowy Egrets foraged at higher densities in brackish-marine habitats than freshwater sites. Snowy Egrets utilized all brackish-marine habitats at similar densities while Tricolored Herons showed a preference for small creeks over other brackish-marine habitats. Although there were differences in habitat use Great Blue and Little Blue herons, no clear salinity preferences were observed. Recommendations for the conservation of wading bird foraging habitats are discussed.

INTRODUCTION

Population levels of wading birds depend on the existence and conservation of foraging habitat (Kushlan 1978). Availability of food may be the single most important factor limiting the distribution and abundance of nesting wading birds (Frederick and Spalding 1994). Understanding the distribution and relative use of wading bird foraging habitats is not only important in understanding their feeding ecology but also in prioritizing wetland habitats for conservation.

Several studies (Bancroft et. al 1994; David 1994; Erwin 1983, 1985; Frederick and Bildstein 1992; Hoffman et. al 1994; Ramo and Busto 1993; Smith 1995) have documented the use of foraging habitat by wading birds on a landscape scale. In south Florida, seasonal changes in the quantity, timing, and distribution of waterflow in the impounded water conservation areas has been shown to effect the density of foraging and nesting wading birds (Bancroft et al 1994, Hoffman et al 1994). Similarly, David (1994) found high water levels significantly reduced the number of foraging wading birds in the littoral zone around Lake Okechoobee, Florida. Although these studies were comprehensive, they were conducted in non-tidal freshwater wetland systems in south Florida. Few studies have examined the seasonal distributions of foraging wading birds in more temporally predictable estuarine habitat.

On the coast of South Carolina, wading birds use a variety of wetlands for foraging including tidally-influenced marshes and impounded wetlands. Christy et al. (1981) examined the seasonal abundance of wading birds foraging in a 3000 hectare salt marsh near North Inlet, South Carolina. Although the seasonal wading bird use of salt marsh habitat was documented, researchers did not examine the extent to which birds utilize other elements of the estuary system including river drainages and bay shoreline.

Because of the concern over increasing residential and industrial development, the South Carolina Department of Natural Resources initiated a study in 1994 to determine the monthly abundance and habitat use of wading birds feeding in the Charleston Harbor Estuary system. The objectives of our study were to: (1) document the seasonal distribution and abundance of foraging wading birds in the

Charleston Harbor Estuary; (2) determine if there is a relationship between the abundance of wading birds and fish biomass; (3) compare gross patterns of wading bird use between elements of the estuary system including: river drainages, the harbor, and surrounding salt marsh habitats; and (4) compare densities of foraging wading birds in three brackish-marine habitat types [mudflat, small creeks, estuarine shoreline] and four freshwater habitats [formerly impounded ricefields, impounded wetlands, riverine shoreline, and small creeks]. The results of this study will be used to provide baseline data to compare with future surveys and to make recommendations for the conservation of wading bird foraging habitat.

Materials and Methods

We studied foraging wading birds from January through December 1994 in the Charleston Harbor Estuary located on the south-central coast of South Carolina. The study area included portions of the Stono, Wando, Ashley, and Cooper rivers; Charleston Harbor; and surrounding salt marsh habitat (Figure 1). The Stono, Ashley, and Wando rivers and the Charleston Harbor are tidally influenced with very little freshwater inflow. Mean tidal range is approximately 1.6 m in Charleston Harbor (Van Dolah et al. 1990). The dominant vegetation on the shoreline is characteristic of salt and brackish marsh dominated by Smooth Cordgrass *Spartina alterniflora*. Surface salinities range from 7-27 ppt (Van Dolah et al. 1990). The salt and brackish marshes are drained with small inter and sub-tidal creeks. The Cooper River is the major source of freshwater entering the estuary. The upper portions of the east and west branch of the Cooper river are characterized by old rice fields with broken dikes along the river banks. The tidal freshwater marshes are characterized by Giant Cordgrass *Spartina cynosuroides* , Giant Cutgrass *Zizaniopsis miliacea*, Pickerel-weed *Pontedaria cordata,* Soft-stem Bulrush *Scirpus validus*, Sawgrass *Cladium jamaicense*, cattails *Typha spp.,* and Common Threesquare *Scirpus americanus* (Tiner 1977). Several freshwater impoundments are still intact and are managed primarily for waterfowl. Surface salinities range from 0 ppt near the convergence of the east and west branch to 19 ppt near the harbor proper (Van Dolah et al 1990).

We divided the study area into six survey routes representing four river drainages, Charleston Harbor and surrounding salt marsh habitats (Figure 2). Each month, we conducted boat surveys of 759.9 km of shoreline over a five day period. Because preliminary boat and aerial surveys indicated a large percentage of birds roosted at high tide, we conducted surveys during the four hour period representing two hours prior to and following low tide. Most of the salt marsh and upper creek substrate were exposed at this tidal stage and were not considered available feeding habitat for wading birds. We began surveys when the beginning of the 4 hour survey period occurred 1 hour after dawn. We did not conduct surveys in winds over 10 knots or in rain; we conducted canceled surveys on the next available day. We completed all surveys in a 7 day period. To maintain consistency, the same observer conducted all surveys.

We conducted shoreline surveys from a 5.2 m motor boat traveling at approximately 32 km/hr. We used a 2.4 m aluminum ladder mounted in the center of the boat to survey mudflats and impounded wetlands adjacent to shoreline habitat. When we encountered a wading bird, we maneuvered the boat as close as possible without flushing the bird and recorded the location using a Magellan Nav 5000D GPS unit. In addition, we categorized foraging habitat as: 1) brackish-marine habitats- a) mudflat, b) small creek, c) estuarine shoreline and, 2) freshwater habitats- a) formerly impounded ricefield, b) impounded wetland, c) small creek, d) riverine shoreline. Because the study area contains numerous small mudflats which are difficult to distinguish from estuarine shoreline, we included only birds using large (> 1 km of shoreline length) mudflats in this habitat type. Small creeks had maximum widths of 90 m at the mouths and wide meanders, however, most sections were less than 50 m in width.

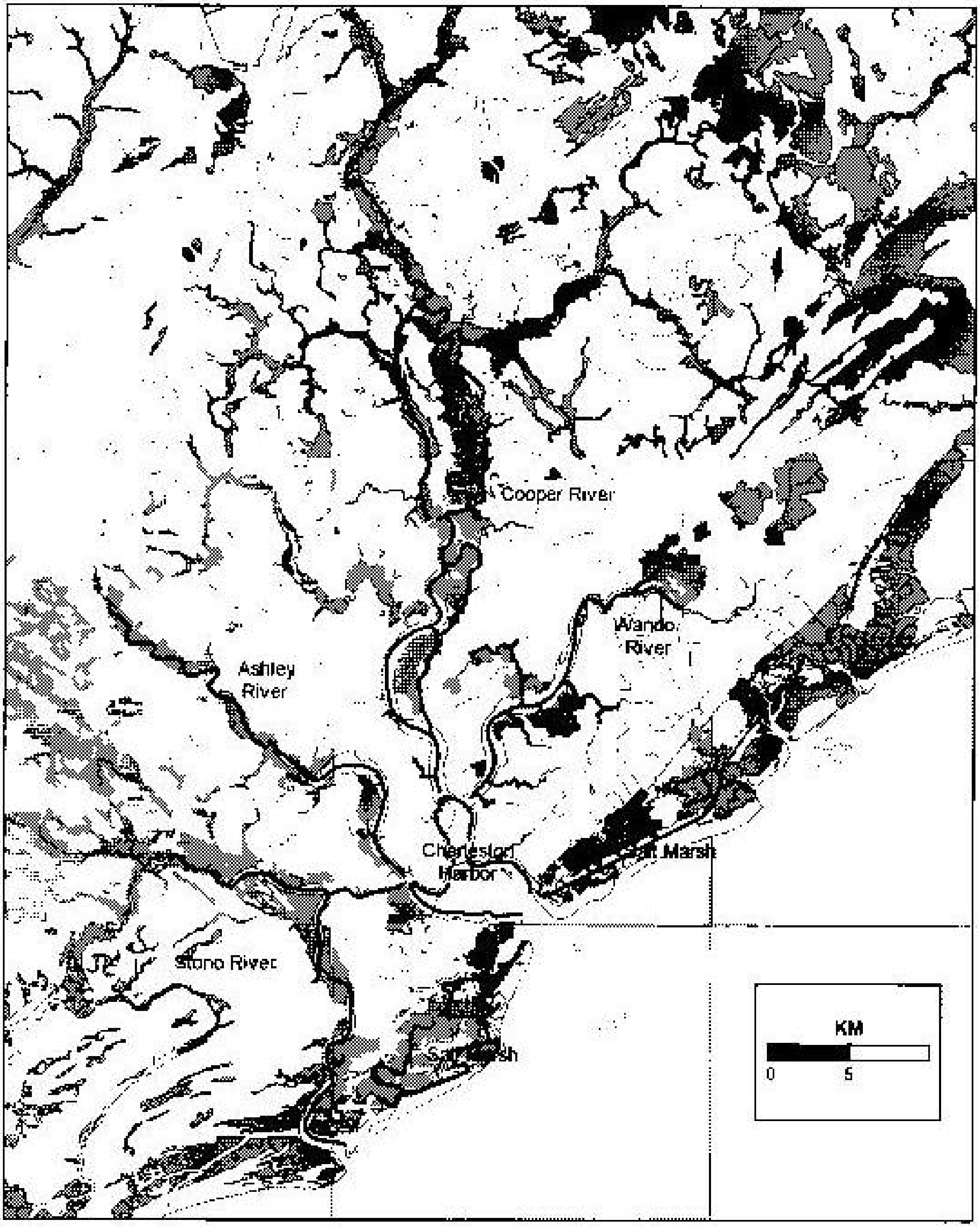

Figure 1. Monthly survey routes for foraging wading birds in the Charleston Harbor Estuary, South Carolina, 1994.

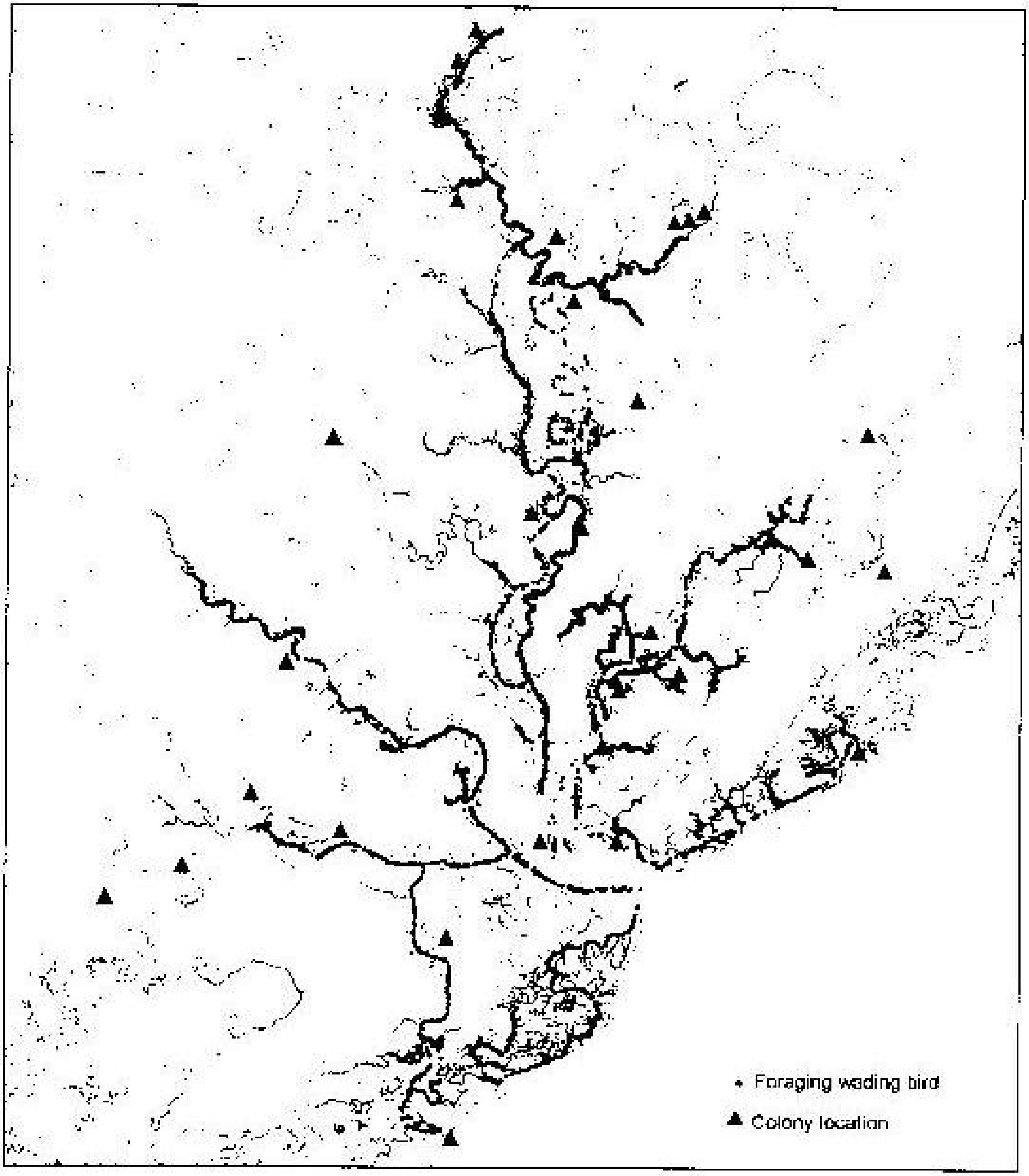

Figure 2. Wading bird feeding and nesting locations in the Charleston Harbor Estuary, South Carolina, 1994.

We restricted our analysis to the 10 most abundant species found during our study including: Great Egret *Casmerodius albus*, Snowy Egret *Egretta thula*, Great Blue Heron *Ardea herodias*, White Ibis *Eudocimus albus*, Tricolored Heron *Egretta tricolor*, Little Blue Heron *Egretta caerulea*, Yellow-crowned Night-Heron *Nycticorax violaceus*,Black-crowned Night -Heron *Nycticorax nycticorax*, Wood Stork *Mycteria americana*, and Glossy Ibis *Plegadis falcinellus*.

Associations between wading birds and fish biomass

We compared the monthly abundance of wading birds with overall fish biomass using fish data from the Marine Division of the S. C. Department of Natural Resources collected at four representative sites within the study area from September 1986 to August 1987 (Hoffmann 1991). Although fish and bird samples were not collected within the same year, seasonal abundance of local fish biomass are known to be comparable between years (C. Wenner, SCDNR, pers. comm.). We used Spearman rank correlation analysis to examine the relationship between monthly wading birds (all species combined) and fish biomass (all species combined). In addition, we compared the abundance of the six most abundant species of wading birds and overall fish biomass. Because of the large number of correlations presented, we used Bonferroni's correction for probability levels (P = 0.05 = 0.006).

Comparison between survey routes

We calculated wading bird foraging densities for each survey route by month. Because the data was not normally distributed, we used a ranked-sign, one-way ANOVA to test for differences in densities of wading birds between survey routes (SAS Inst. 1988). We used Ryan-Einot-Gabrial-Welsh multiple comparison procedure to examine differences in the means. We used Bonferroni's correction for probability levels (P = 0.05 = 0.025) because of multiple ANOVAs (see below).

Comparison between habitat types

In order to examine habitat use on a finer scale, we calculated densities of wading birds utilizing mudflat, small creeks, estuarine shoreline, formerly impounded ricefields, impounded wetland, and riverine shoreline. We used a rank-sign, one-way ANOVA to test for differences in overall wading bird densities between habitat types (SAS Inst. 1988) because data was not normally distributed. We used Ryan-Einot-Gabrial-Welsh multiple comparison procedure to examine differences in means at a $P < 0.025$. Because ANOVAs for survey route and habitat use were calculated from the same data set, we used Bonferroni's correction for probability levels ($P = 0.05 = 0.025$).

Comparisons between foraging and nesting abundance

We conducted aerial surveys for nesting activity of 62 historic colony sites (S.C. Colonial Waterbird Database 1995) within 10 km of the survey route. We extended the colony survey an additional 5 km outside the study area to ensure we were not missing any large colonies just outside the boundary. We censused colonies containing < 20 nests with the aerial count technique, and all other colonies with the ground count technique (Dodd and Murphy 1995).

We made comparisons between nesting and feeding populations in May because at this stage in their nesting chronology at least one adult is in attendance of the nest. The number of nests should correspond to the number of birds foraging in the study area unless nonbreeding or migratory birds are present.

We compared the species composition of foraging and nesting populations by calculating the relative percentages for each species during the month of May (SAS Inst. 1988). We used a χ^2 test to determine if the percent composition differed between foraging and nesting populations.

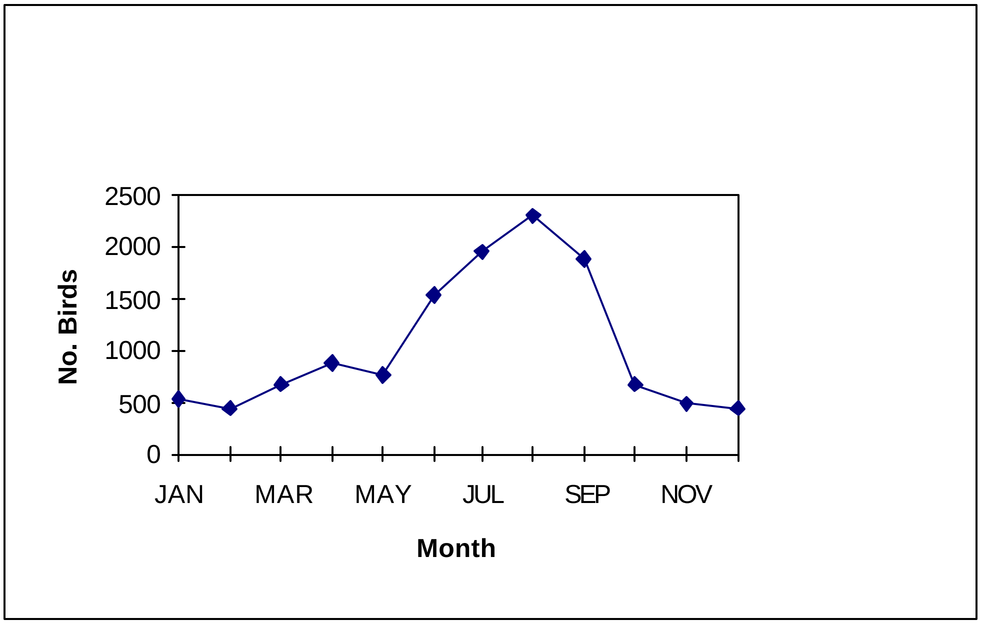

Figure 3. Number of foraging wading birds (all species combined) on monthly boat surveys in the Charleston Harbor Estuary, South Carolina, 1994.

RESULTS

A total of 12,637 foraging wading birds were observed during monthly boat surveys in 1994 (x = 1053.08 birds, SD = 678.57; Table 1). Wading bird abundance was highest in the summer (June-September) with numbers ranging from 1,546-2,309 birds (Figure 3). By contrast, fall and winter (October-February) totals were consistently lower ranging from 438 - 687 birds (Table 1). Monthly wading bird foraging densities ranged from 0.58 - 3.04 birds/km of shoreline habitat (x = 1.39 birds/km, SD = 0.89).

Great and Snowy egrets comprised the majority of the increase in birds in the spring and summer (Figure 4). Great Egrets accounted for 46, 39, and 47 % of total foraging birds during Table 1. Relative Abundances of foraging wading birds (all species combined) in the Charleston Harbor Estuary, South Carolina, 1994.

Survey Route	Shoreline(km)	Jan	Feb	Mar	Apr	May	Jun
Cooper River	280.5	145	162	378	432	389	565
Wando River	117.4	107	85	54	110	156	347
Salt Marsh	141.0	150	43	69	136	130	288
Ashley River	88.9	77	76	80	54	47	98
Stono River	93.1	39	43	47	91	38	103
Charleston Harbor	38.8	12	35	47	56	15	145
Total	759.9	530	444	675	879	775	1,546

Survey Route	Shoreline(km)	Jul	Aug	Sep	Oct	Nov	Dec	Total
Cooper River	280.5	832	801	611	202	242	186	4,945
Wando River	117.4	352	407	323	199	66	63	2,269
Salt Marsh	141.0	391	430	337	144	41	79	2,238
Ashley River	88.9	165	283	222	75	109	58	1,344
Stono River	93.1	132	237	197	45	14	40	1,026
Charleston Harbor	38.8	99	151	193	22	28	12	815
Total	759.9	1,971	2,309	1,883	687	500	438	12,637

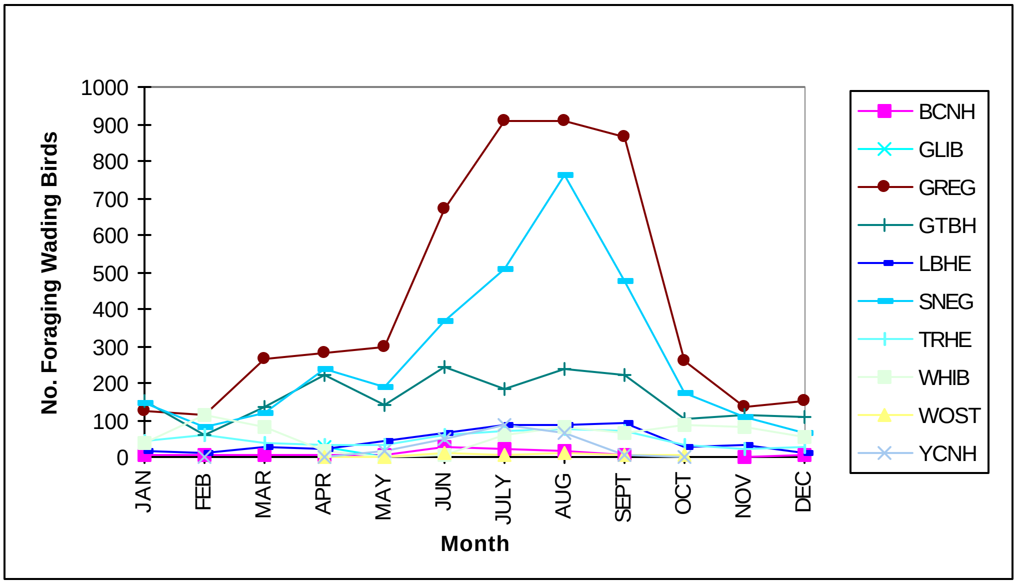

Figure 4. Number of foraging wading birds on monthly boat surveys in the Charleston Harbor Estuary, South Carolina, 1994. BCNH=Black-crowned Night-Heron, GLIB= Glossy Ibis, GREG= Great Egret, GTBH= Great Blue Heron, LBHE= Little Blue Heron, SNEG= Snowy Egret, TRHE= Tricolored Heron, WHIB= White Ibis, WOST= Wood Stork, YCNH= Yellow-crowned Night-Heron.

July, August and September respectively. Great Blue Heron numbers increased slightly during spring and summer. The remaining species occurred at consistently lower numbers during all months.

Associations between wading bird abundance and fish biomass

We found a significant and positive relationship between the monthly abundance of wading birds and monthly fish biomass (Table 2). In addition, monthly abundance of the two most common species, Great and Snowy Egrets, and Little Blue Herons were correlated with fish biomass. However, abundance of Great Blue Heron, Tricolored Heron, and White Ibis did not correlate with fish biomass (Table 2).

Table 2. Spearman rank correlation analysis between the monthly abundance of wading birds (all species combined) and total fish biomass in the Charleston Harbor Estuary, South Carolina, 1994.

Species	df	R value	P > R
Wading birds	11	0.80	0.002 *
Great Egret	11	0.83	0.0008 *
Great Blue Heron	11	0.65	0.02
Little Blue Heron	11	0.83	0.0008 *
Snowy Egret	11	0.78	0.003 *
Tricolored Heron	11	0.35	0.026
White Ibis	11	-0.39	0.21

* = significant at a $P < 0.007$.

Comparison between survey routes

Nine of 10 species were observed foraging in the Ashley, Wando, Cooper, Stono, and salt marsh survey routes. Glossy Ibis were only observed in the Stono and salt marsh routes. Little Blue Herons were not observed on the harbor or Stono River survey routes. There was no difference in overall densities of wading bird foraging densities between survey routes ($F = 0.96$, $df = 5$, $P = 0.45$).

Comparison between habitat types (within survey route)

Wading birds (all species combined) foraged on mudflats, brackish-marine small creeks, and formerly impounded ricefields at higher densities than other habitats ($F = 11.07$, $df = 6$, $P = 0.0001$; Table 3). However, we observed interspecific variation in densities of foraging birds (Table 4).

Table 3. Comparison of foraging wading bird densities (all species combined) by habitat type in the Charleston Harbor Estuary, South Carolina, using rank-sign ANOVA and Ryan-Einot-Gabrial-Welsch Multiple Range Test.

Habitat	Salinity[a]	$\bar{x}$[b]	SD	Significance[c] Groupings
Large Mudflat	Brackish-Saline	3.60	2.82	A
Formerly Impounded Ricefield	Fresh	2.62	1.73	A
Small Creek (< 50 m)	Brackish-Saline	2.47	1.75	A
Estuarine Shoreline	Brackish-Saline	1.06	0.69	B
Impounded Wetland	Fresh	0.97	0.82	B
Riverine Shoreline	Fresh	0.65	0.36	B
Small Creek (< 50 m)	Fresh	0.56	0.27	B

a Fresh: 0 ppt.; Brackish-Saline: 7-32 ppt.

b Mean number of birds/km of shoreline habitat.

c Habitat types with the same letter are not different (P>0.025) based on Ryan-Einot-Gabrial-Welsch multiple comparison procedure.

Great Egrets also foraged in higher densities on mudflats, brackish-marine small creeks, and formerly impounded ricefields. Tricolored Herons and Snowy Egrets generally foraged at higher densities in brackish-marine habitats than freshwater sites. Snowy Egrets utilized all brackish-saline habitats at similar densities while Tricolored Herons showed a preference for small creeks over other brackish-marine habitats. With the exception of formerly impounded ricefields, White Ibis also foraged at higher densities in brackish-marine habitats. Although densities of Great Blue and Little Blue herons varied between habitats, no clear preferences were observed due to overlap of significance groupings.

Table 4. Individual species comparison of foraging densities by habitat type in the Charleston Harbor Estuary, South Carolina, using rank-sign ANOVA and Ryan-Einot-Gabrial-Welsch Multiple Range Test.

				Brackish-Saline Habitats[a]				Freshwater Habitats[a]		
Species	F	df	P>F	Mudflat[b]	Small creek	Estuarine shoreline	impounded ricefield	Formerly Impounded wetland	Small creek	Riverine shoreline
Great Egret	6.42	6	0.0001	A	A,B	B,C	A	B,C	C	B,C
Snowy Egret	49.08	6	0.0001	A	A	A	B	C	B,C	B,C
Great Blue Heron	4.54	6	0.0005	A,B	A,B	C	A	A,B,C	B,C	A,B,C
White Ibis	7.18	6	0.0001	A	B,C	A,B	A,B	C	C	C
Tricolored Heron	53.05	6	0.0001	B	A	B	C	D	C,D	C,D
Little Blue Heron	3.74	6	0.0026	B,C	A,B	C	A	A,B,C	A,B,C	A,B,C

a Freshwater Habitat: 0 ppt.; brackish- Saline Habitat: 7-32 ppt.

b Survey routes with the same letter are not different (P>0.025) based on Ryan-Einot-Gabrial-Welsch multiple comparison procedure.

Seasonal wading bird abundance and nesting comparison

During May, the species composition of wading birds differed between foraging and nesting distributions ($\chi^2 = 41.59$, df = 9, P < 0.001). Great Egrets and Tricolored Herons exhibited the largest differences between foraging and nesting populations (Table 5).

DISCUSSION

Seasonal abundance of wading birds

The abundance of wading birds foraging on the Charleston Harbor Estuary followed the same seasonal pattern as reported by Christy et al. (1981) for a South Carolina salt marsh (Figure3). Numbers of wading birds remained stable throughout the winter at low densities followed by a

Table 5. Comparison of the relative proportions of foraging and nesting wading birds during May in the Charleston Harbor Estuary, South Carolina, 1994.

Species	No. feeding birds	% of total	No. nesting birds (10 Km)	% of total
Black-crowned Night-Heron	5	0.7	71	4.2
Glossy Ibis	1	0.1	0.0	0.0
Great Egret	298	41.1	182	10.8
Great Blue Heron	139	19.2	367	21.8
Little Blue Heron	45	6.2	95	5.6
Snowy Egret	188	25.9	409	24.3
Tricolored Heron	33	4.6	402	23.9
White Ibis	1	0.1	0.0	0.0
Wood Stork	1	0.1	136	8.1
Yellow-crowned Night -Heron	14	1.9	23	1.4
Total	725		1685	

large increase in birds during the summer months (June-September). Christy et al. (1981) found a proportionally larger increase in foraging birds in the spring (March-May) than recorded in our study. This increase was probably due to the close proximity (< 2 km) of a large White Ibis colony near their North Inlet study site (S. C. Colonial Waterbird Database 1994). White Ibis did not nest within 10 km of our study area in 1994 and occurred at low densities in our surveys (S.C. Colonial Waterbird Database 1995).

Seasonal wading bird abundance and nesting comparison

The large increase in wading bird abundance in June is primarily a result of two species: Great Egret and Snowy Egret (Figure 4). These species represent a combined total of 67% of the birds observed foraging during June. Several species which occurred at consistently low abundances on the survey routes include: Black-crowned Night-Heron, Glossy Ibis, Little Blue Heron, Tricolored Heron, White Ibis, Wood Stork and Yellow-crowned Night-Heron. The low abundances of these species may be a result of their relative lack of nesting within the study area (Table 6). In addition, we only evaluated diurnal feeding distributions, which may account for the relatively few observations of primarily night-feeding species (e.g. night herons).

The greater proportion of foraging Great Egrets compared to nesting egrets may be a result of the loss of the Drum Island nesting colony (Table 6). Drum Island, in Charleston Harbor, was once the largest wading bird colony on the east coast (Osborn and Custer 1977). This colony contained 781 Great Egret nests in 1985, but was abandoned in 1988 due to mammalian and avian predators (Post 1990). Great Egrets attempted to nest in two other sites in the Charleston Harbor in subsequent years (S. C. Colonial Waterbird Database 1995), but in 1994 were no longer nesting within 10 km of the study site. If we add the 781 nests to the 1994 nesting population, the proportion of nesting and feeding birds would be comparable. Because the area surrounding Charleston Harbor is highly developed, the discrepancy in foraging and nesting populations may be due to a lack of nesting sites within the area.

Table 6. Comparison of the relative proportions of foraging and nesting wading birds during the month of May in the Charleston Harbor Estuary, South Carolina, 1994

Species	No. feeding birds	% of total	No. nesting birds(10 Km)	% of total
Black-crowned night heron	5	0.7	71	4.2
Glossy Ibis	1	0.1	0.0	0.0
Great Egret	298	41.1	182	10.8
Great Blue Heron	139	19.2	367	21.8
Little Blue Heron	45	6.2	95	5.6
Snowy Egret	188	25.9	409	24.3
Tricolored Heron	33	4.6	402	23.9
White ibis	1	0.1	0.0	0.0
Wood Stork	1	0.1	136	8.1
Yellow-crowned night heron	14	1.9	23	1.4
Total	725		1685	

However, this explanation assumes that the Great Egrets observed foraging in the estuary have not been breeding since 1990. Alternatively, Great Egrets formerly nesting on Drum Island may have relocated to other colonies in South Carolina. In addition, some of the birds we observed during our surveys may have been migrating or non-breeding birds. Further research will be necessary to determine the proportion of non-breeding wading birds utilizing wetland habitats during the nesting season.

In contrast to Great Egrets, Tricolored Herons nested in a greater proportion than they foraged in the Charleston Harbor Estuary. This may be due to the use of microhabitats by Tricolored Herons which could not be censused by boat. However, regurgitation samples indicate that Tricolored Herons are feeding primarily on salt water prey (Post 1990) and should have utilized habitats included in our survey routes. It is also possible that the discrepancy is a result of biased sampling due to the Tricolored Herons dark coloration. Further study of foraging microhabitats used by Tricolored Herons will be necessary to determine whether our sampling was biased.

Correlations between wading birds and fish biomass

The monthly abundance of wading birds utilizing wetland habitats in the Charleston Harbor Estuary was correlated with the seasonal abundance of fish biomass. The spring increase in fish biomass is primarily a result of two species: the Common Mummichug *Fundulus heteroclitus* and Spot *Leiostomas xanthurus*. During May, these species accounted for 81% of the total biomass at sampling stations in the estuary. The size classes of *Fundulus* spp. and *L. xanthurus* during the spring and summer are within normal prey sizes (2-12 cm) taken by wading birds (Hoffman 1991). Post (1986) reported that over 60% of Tricolored Herons diet was composed of killifishes *Fundulus* spp. at the Drum Island Colony in Charleston Harbor. Maccarone and Parsons (1994) found Common Mummichug to be the most important prey species for Snowy and Great egrets on Staten Island, New York. Ultimately, wading birds are a component of the estuarine ecosystem, and the conservation of wading bird populations in South Carolina is tied to the protection of the entire system including seasonal and resident fish stocks.

Comparisons between survey routes and habitat types

On a gross scale, all elements of the tidal estuary system appear to be equally important as foraging habitat for the wading bird guild. We did not detect differences in the densities of wading birds feeding among river drainages, the harbor, or surrounding salt marsh habitat.

On a finer scale, wading birds utilized mudflats, brackish-marine small creeks, and formerly impounded ricefields at higher densities than other habitats (Table 3). Because foraging wading birds are limited by water depth (Custer and Osborn 1978), we suspect that the high use of formerly impounded ricefields and mudflats is a result of the relatively large amount of shallow foraging habitat (<25 cm) in these habitats. The banks on the edges of most tidal creeks are steep and provide relatively less area to forage as the tide recedes. In addition, the marsh habitat adjacent to the creeks is composed of a dense stand of *Spartina* which is generally avoided for foraging (Custer and Osborn 1978, Hoffman et al 1994, Maccarone and Parsons 1994).

As with other studies, Snowy Egrets and Tricolored Herons utilized mainly brackish and marine habitats in the Charleston Harbor Estuary (Busto and Ramo 1993, Custer and Osborn 1978, Post 1990). Snowy Egrets utilized brackish-marine habitats at similar densities, whereas Tricolored Herons exhibited a preference for small creeks over mudflats and estuarine shoreline.

Although densities of Great Blue and Little Blue herons differed among habitats, our results suggest that these species did not exhibit a preference for any one habitat types. Our results contrast with those of Busto and Ramo (1993) and Custer and Osborn (1978) who found these species feeding mainly in freshwater habitats. This difference may be a result of our concentrating on tidally influenced wetlands. Both species are known to use isolated freshwater wetlands (M. Dodd, pers. obs.), and inclusion of this habitat type in our study may have changed our results.

Conclusions and Management Recommendations

Wading birds are a component of the estuarine ecosystem. Their conservation is dependent on the overall health of the system and particularly resident fish stocks. All elements of the Charleston Harbor Estuary including river drainages, Charleston Harbor, and surrounding salt marshs were used at similar densities. However, on a finer scale, wading birds utilized large mudflats, formerly impounded ricefields, and brackish-marine small creeks at higher densities than estuarine or riverine shoreline, small creeks (freshwater), and impounded wetlands.

At some point, increasing residential and commercial development in the Charleston Harbor Estuary will adversely affect the quality and quality of wading bird foraging habitats. Human activities are a major factor in the disturbance of foraging wading birds (Burger 1981, Bratton 1990). In the Charleston Harbor Estuary, potential disturbance from residential development includes increased human activity from boat traffic, dock structures, and upland activity adjacent to foraging habitats. Unfortunately, the literature lacks quantified studies of human interference with foraging behavior (Bratton 1990). Although we cannot quantify the point at which human disturbance degrades wading bird foraging habitat, we can make recommendations to minimize disturbance to birds as development occurs.

Because wading birds used all major components of the estuary at similar densities, management recommendations apply to the study area in general. Although there were differences in the use of habitat types, wading birds generally occurred at low densities in the Charleston Harbor Estuary (range 0.58-3.04 birds/km). Because mudflats, brackish-marine small creeks, and formerly impounded ricefields represent only a portion of the total shoreline habitat, protecting these habitats alone is probably not sufficient to maintain current wading bird populations. Although we recommend prioritizing by habitat type, a level of protection must be applied to all wading bird foraging habitats to maintain current densities of wading birds.

Habitats used at relatively higher densities, such as mudflats, brackish-marine small creeks, and formerly impounded ricefields should be protected from human disturbance. Boat traffic is generally not heavy in mudflats and ricefields due to their shallow water depths (M. Dodd pers. obs.). However, other portions of the estuary are more susceptible. Bratton (1990) found that 74 - 83% of wading bird groups were flushed or altered their behavior in response to a passing boat in a tidal creek (35-45 m maximum width), whereas, only 15 - 34% of wading bird groups responded to boat traffic on the shoreline of a large estuarine sound. Although it is unclear to what extent wading birds could acclimate to increasing boat traffic, a strategy for placement of boat ramps, dock structures, and marinas should attempt to minimize boat traffic in small tidal creeks (< 28 m maximum width), mudflats, and formerly impounded ricefields. We suggest that docks should be placed primarily along wide channels (> 50 m) and bay shoreline while avoiding large mudflats and formerly impounded wetlands. Community docks are preferable to numerous single-dwelling dock structures in order to conserve available foraging habitat for wading birds.

In addition, wading birds may be susceptible to human disturbance from upland sites adjacent to foraging habitats. In order to protect wading birds form upland disturbances, we suggest vegetative buffers where possible. Vegetative buffers serve the dual purpose of reducing human disturbance on upland edges and providing roosting habitat in close proximity to foraging sites. The size (width) of an effective barrier is variable depending on the amount of screening vegetation. However, mature trees, particularly those with large lateral limbs, and dead snags should be retained to provide roost habitat.

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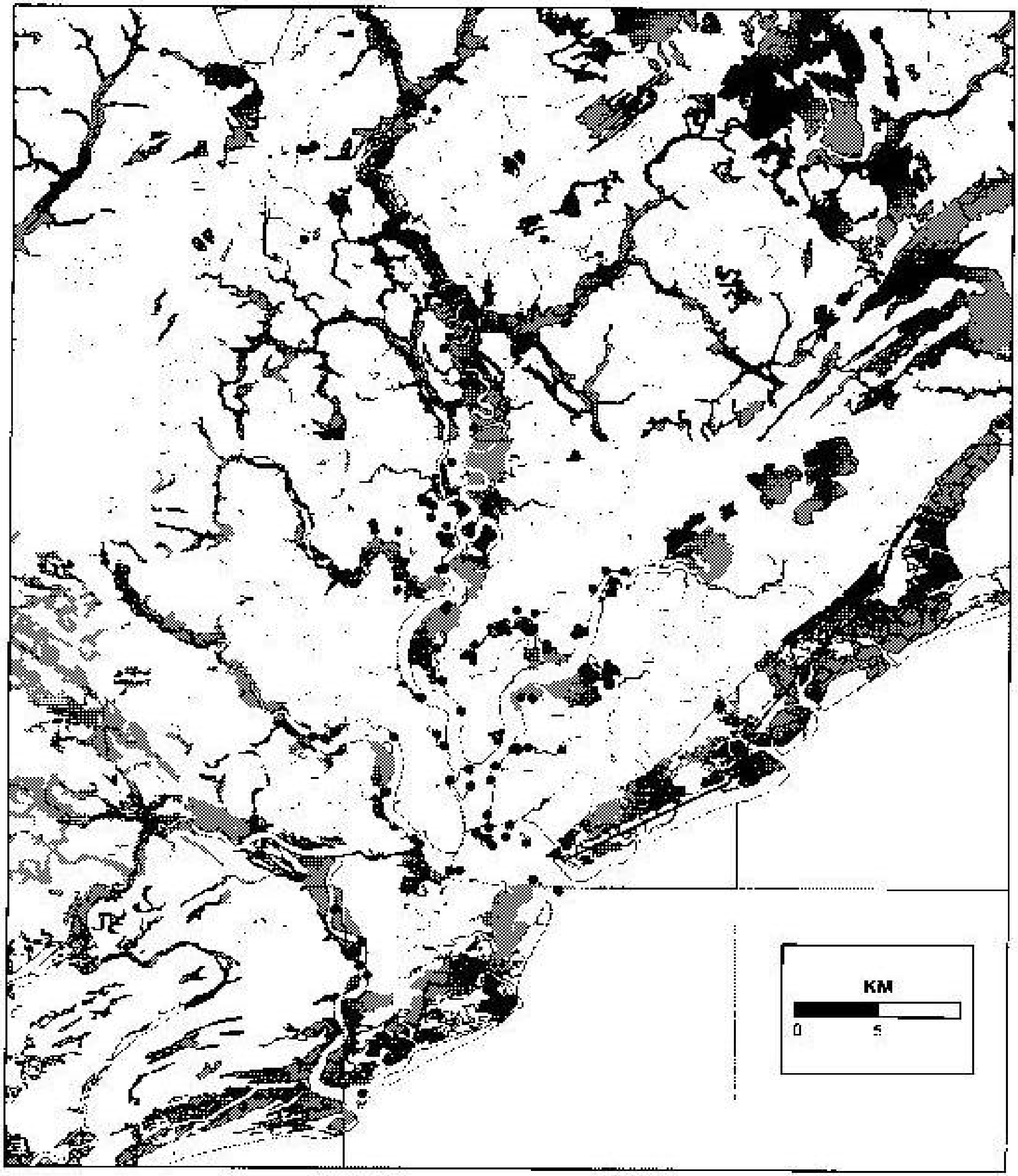
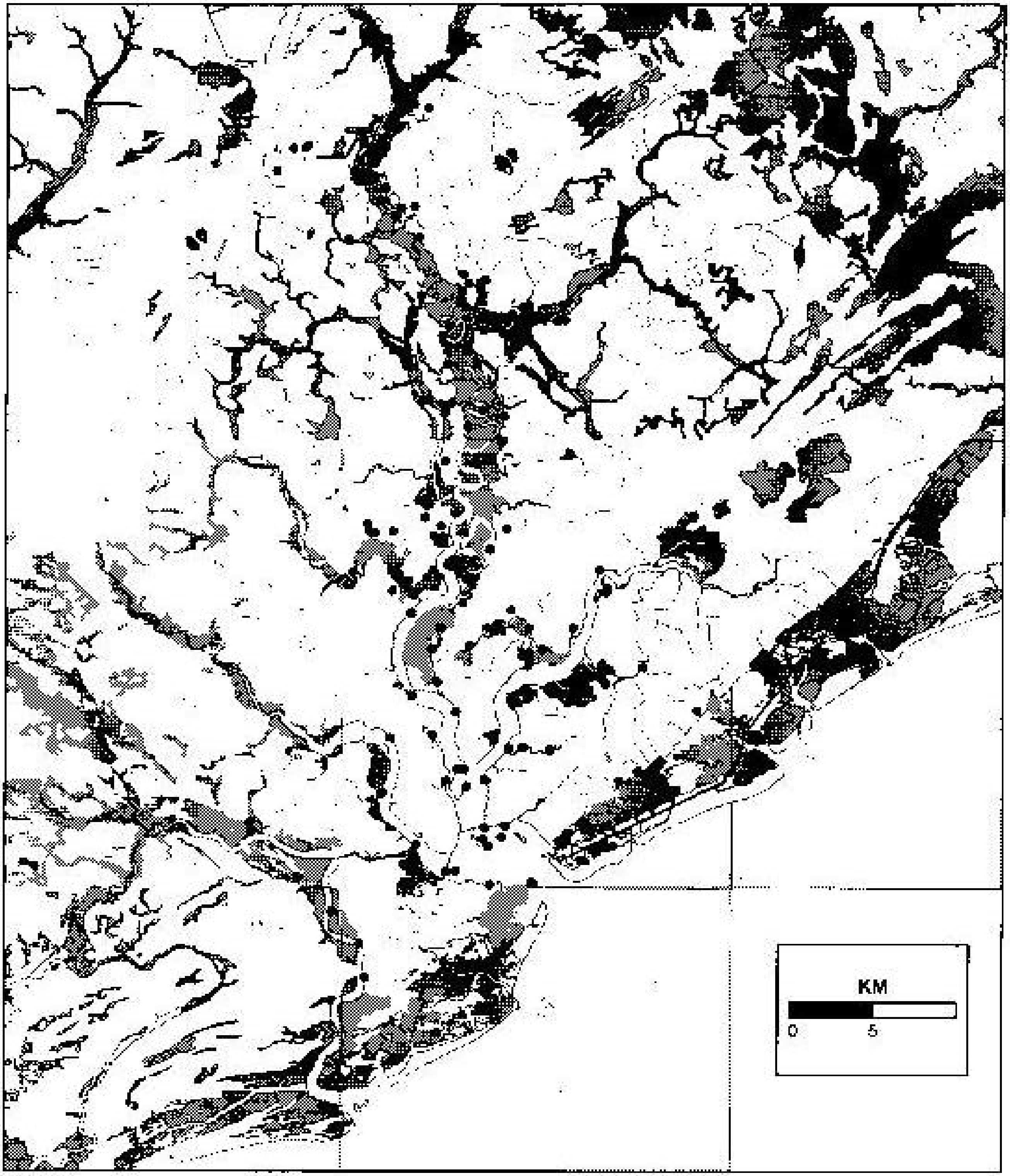
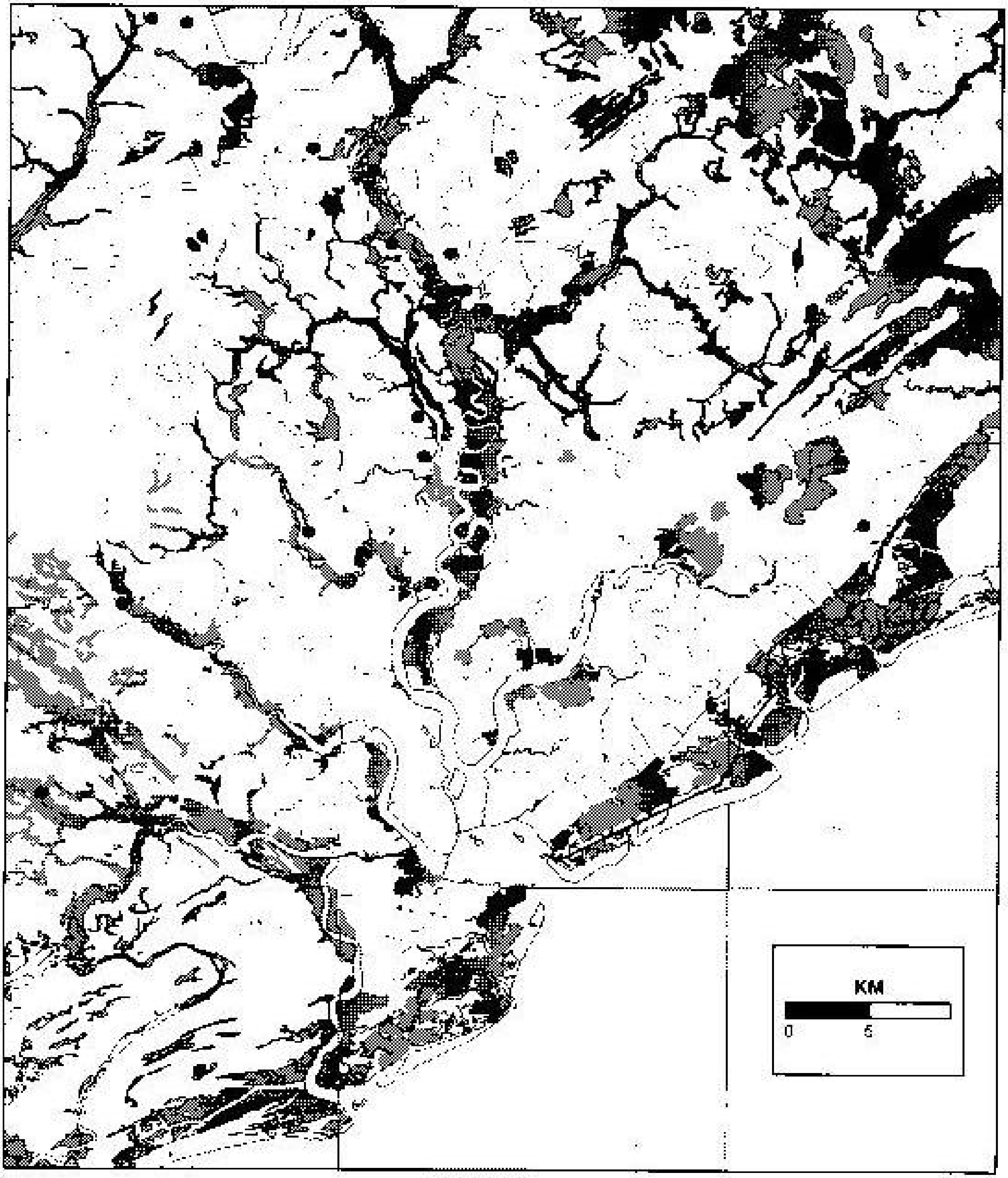


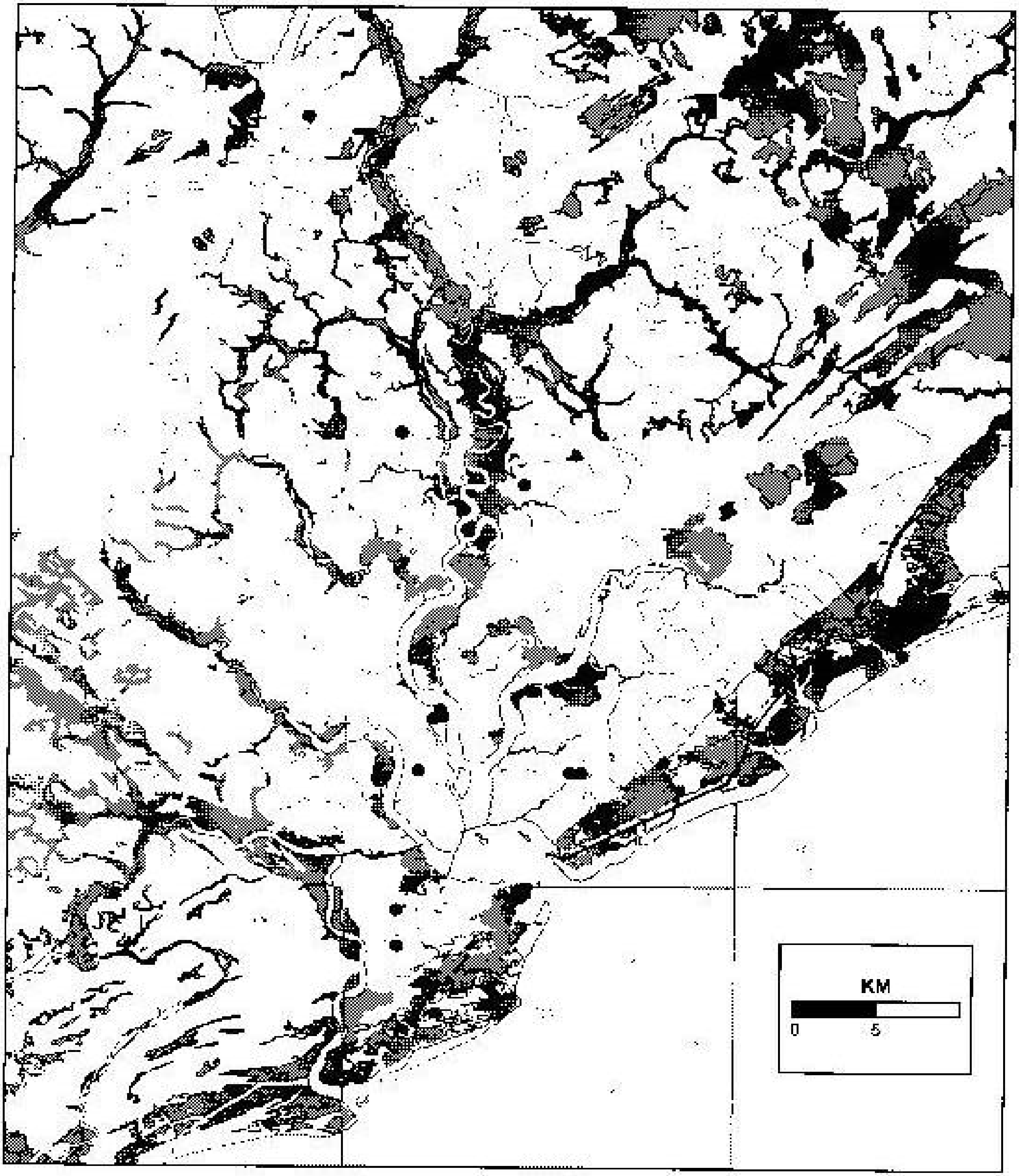
Appendix I. Osprey nest locations in the Charleston Harbor Estuary, South Carolina, 1993.



Appendix II. Osprey nest locations in the Charleston Harbor Estuary, South Carolina, 1994.



Appendix III. Bald Eagle nest locations in the Charleston Harbor Estuary, South Carolina, 1994.



Appendix IV. Least Tern nesting locations in the Charleston Harbor Estuary, South Carolina, 1994.